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EFFECT OF TEMPERATURE ON BLACK SPOT IN LONG ISLAND AND RED RIVER VALLEY POTATOES[1]

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(Accepted for publication July 27, 1951)

Black spot (internal black spot) of potatoes is a serious problem in Suffolk County, Long Island, N. Y. (1, 3). During recent years it has been observed by the senior writer in potatoes shipped to the New York, N. Y. market, from Maine, Massachusetts, Connecticut, Rhode Island, New Jersey, Pennsylvania, and Nassau and Steuben Counties, New York. Findlen has found black spot prevalent in the Red River Valley area of Minnesota and North Dakota.

Wiant (4) showed the importance of bruising as the immediate cause of black spot in susceptible Long Island potatoes. Scudder, Jacob and Thompson (2) reported extensive field experiments to determine the factors predisposing potatoes to black spot upon bruising. A review of the literature pertinent to black spot and to a closely related if not an identical European potato disorder is found in the latter publication.

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[1] Report of a study of which certain phases were carried on under the Research and Marketing Act of 1946. RM : 174 and 320.
[2] Senior Pathologist. [3] Associate Horticulturist. [4] Assistant Pathologist.

The present paper summarizes temperature studies on black spot conducted with Green Mountain potatoes grown near Riverhead, Long Island, during 1944 to 1949 and with Triumph (Bliss Triumph) and Irish Cobbler potatoes grown near East Grand Forks, Minnesota, in 1949.

Tests with Potatoes from Long Island

Limited observations made on the stored 1943 crop indicated that black spot was reduced by warming susceptible tubers for 3 days prior to bruising (4). During the following season 4 temperature-conditioning tests were therefore made with potatoes of the 1944 crop. In 3 of the tests tubers with pressure spots[2] were selected by hand from the face of partially worked commercial bins and the pressure spots marked with india ink. The tubers were then taken by car to the Market Pathology Laboratory at New York City and divided into replicate lots, and one lot was placed in each of the several temperature chambers for conditioning as indicated in table 1. After the tubers were conditioned each marked pressure spot was struck three times, lightly and uniformly, with the rounded smooth handle of a small screw driver in tests 1 and 3 and once lightly with the rounded smooth handle of a pocket knife in test 2.

In all tests (Table 1) the per cent of tubers affected with black spot decreased with an increase in the temperature at which they were conditioned prior to bruising. The most noticeable drop in the percentage of tubers affected with black spot occurred when the conditioning temperature was 65° and above in test 1, from 50° and above in test 2, and 55° F. and above in test 3. Although the tests were not strictly comparable the data suggest slightly greater reduction in black spot by 6 or 7 days' conditioning than by 4 days' conditioning.

Another test of a somewhat different nature was made with tubers of the 1944 crop. Three 100-pound bags of graded potatoes grown near Riverhead were shipped by truck to Beltsville, Maryland, immediately after harvest. One bag was placed at each of the 3 storage temperatures, 36°, 40°, and 50° F. The bags were laid flat on the floor and a 300-pound weight was placed on each. At the end of a fifteen-week storage period (February 2, 1945) the potatoes were examined and two 50-tuber samples selected from each bag. For one sample only tubers with conspicuous pressure spots were selected and the latter were marked with india ink. The tubers of the second sample were those showing the least evidences of pressure spots, and only the firmest appearing areas of the tubers were marked with india ink. The potatoes of both lots were bruised at the

[2] The term "pressure spot" rather than "pressure bruise" is used throughout the present paper in order to avoid confusion with the bruising caused by mechanical blows that are necessary to produce black spot in susceptible tubers. Actually, pressure spots are softened, flattened, or indented areas formed by the pressure of adjacent tubers against each other in the bin. The tissues do not turn black unless mechanically bruised, as stated above.

TABLE 1.—*Development of black spot after mechanical bruising of 1944-crop Long Island Green Mountain potatoes previously conditioned at various temperatures.*

Test and Temperature (° F.) at Which Potatoes Were Held Prior to Striking	Length of Conditioning Period	Tubers in Tests	Pressure Spots Struck	Pressure Spots Affected after Striking		
				Slight Black Spot	Severe Black Spot	Total Black Spot
	Days	Number	Number	Per cent	Per cent	Per cent
Test 1, Dec. 9, 1944:						
37	7	122	257	22	29	51
52	7	123	251	20	10	30
65	7	61	118	6	0	6
95	7	59	106	4	0	4
Test 2, Jan. 13, 1945:						
33	6	94	196	10	75	85
37	6	82	249	6	77	83
43	6	97	230	18	48	66
50	6	90	221	14	4	18
70	6	92	200	3	5	8
90	6	95	247	5	3	8
Test 3, Mar. 12, 1945:						
37	4	60	150	21	45	66
45	4	60	154	20	35	55
50	4	60	164	18	25	43
55	4	60	154	15	11	26
60	4	60	156	11	10	21
70	4	60	153	10	8	18

marked areas as described for test 1 above, after which the tubers were replaced at their respective temperatures for 2 days prior to cutting. It will be noted that at 36° storage black spot developed to about the same degree at pressure spots and elsewhere on the tubers (Table 2). At 40° and 50°, more black spot developed at pressure spots. There was considerably less black spot in the tubers stored at 40° than in those stored at 36° and substantially less in those at 50° than in those at 40° F. storage.

Two temperature-conditioning tests were made in early 1946 with tubers of the 1945 crop. As in the similar tests of the previous season, potatoes with pressure spots were selected from the face of a partially worked commercial bin, the pressure spots marked with india ink and the tubers taken by car to New York. Two replicate lots were placed at each of 5 temperatures on January 14 in the first test and on January 22 in the second test. Pressure spots on half of the lots of each test were struck 3 times with a screw-driver handle after 3 days' conditioning at the several temperatures and half after 7 days' conditioning. When data on black spot were taken 2 days later each spot was rated on the basis

of size and intensity of discoloration in one of 10 classes ranging from 1 to 10. A black spot index was calculated by multiplying the weighted average class value by the percentage of tubers affected with black spot. Thus an index of 1000 would represent the maximum possible with the system used. Since the results from the 2 tests were almost identical they were averaged and are shown graphically in figure 1. Each point on both the 3-day and the 7-day curve represents an average of approximately 200 pressure spots or 85 potatoes. It will be noted that the lower the temperature at which the tubers were conditioned the greater the size of the black spot index. Conversely, the higher the temperature at which they were conditioned prior to bruising the less important was black spot. Temperatures of 52° or higher resulted in maximum protection from black spot development.

A third test initiated on March 27 and conducted in a fashion identical with the preceding ones, with approximately 40 tubers or 80 pressure spots per temperature, gave similar results from 7 days' conditioning prior to bruising except that the black spot index was consistently lower than in the two previous tests. Thus, for temperatures of 33°, 37°, 42°, 52°, 60°, and 70° F. the black spot indexes were respectively 378, 235, 108, 68, 26, and 30.

TABLE 2.—*Development of black spot after mechanical bruising of 1944-crop Long Island Green Mountain potatoes stored fifteen weeks at Beltsville, Maryland.*

Place of Striking and Temperature of Storage (° F.)	Tubers in Test	Areas Struck on Tubers	Areas on Tubers Affected after Striking		
			Slight Black Spot	Severe Black Spot	Total Black Spot
	Number	Number	Per cent	Per cent	Per cent
Struck at Pressure Spots:					
36	51	76	21	68	89
40	48	78	15	31	46
50	52	83	15	7	22
Struck Elsewhere Than at Pressure Spots:					
36	42	69	20	62	82
40	31	62	10	14	24
50	41	82	4	0	4

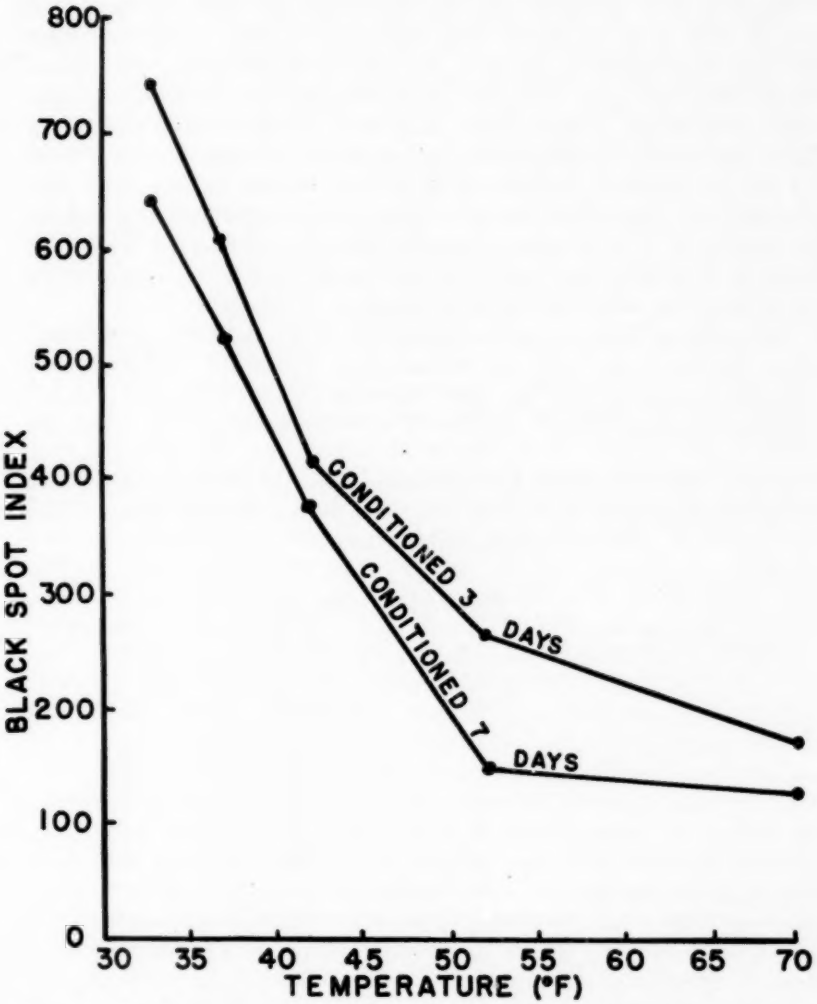

Figure 1. Development of black spot in susceptible potato tubers conditioned for 3 and 7 days respectively at different temperatures prior to bruising. Average of two tests made with 1945-crop Long Island Green Mountain tubers.

From figure 1 it can be seen that the black spot index in the second test of 1946 was consistently lower for tubers conditioned 7 days than for those conditioned only 3 days. In order to obtain further information on the effect of length of time of conditioning on the subsequent development of black spot 2 further tests were made in March 1946 and one in early April 1947, by the methods employed in the earlier tests of 1946 (Table 3). Marked reduction in black spot resulted from 1 day's conditioning and some further reduction occurred when conditioning continued for as long as 2 or 3 days. It appears also that conditioning for 6 to 8 days reduced black spot somewhat, but not markedly, below that which occurred as the result of only 2 or 3 days' conditioning.

Temperature studies were not made with either the 1946 or the 1947 crop. On March 16, 1949, five 100-tuber samples of the 1948 crop were selected at random from bags that had been held for 18 weeks in a 38° F. storage room at New York City. The 100-pound bags from which the

TABLE 3.—*Effect of length of conditioning period at 70° F. on subsequent development of black spot in 1945-crop and 1946-crop Long Island Green Mountain potatoes.*

Test and Length of Conditioning Period	Tubers in Test	Pressure Spots Struck	Black Spot
	Number	Number	Index
Test of Mar. 5, 1946:			
3 hours	46	128	275
4 "	40	117	233
6 "	50	166	344
1 day	45	134	157
2 "	45	141	66
7 "	45	133	57
8 "	44	144	27
Test of Mar. 19, 1946:			
3 hours	20	54	385
4 "	25	70	340
6 "	20	52	308
1 day	20	68	146
2 "	20	62	89
3 "	20	55	89
6 "	20	59	66
Test of Apr. 4, 1947:			
5 hours	26	63	389
1 day	26	65	111
2 "	26	76	39
3 "	26	62	47
4 "	26	57	21
5 "	26	67	28
6 "	26	63	13
7 "	26	64	28

samples were taken had been set upright in the storage room without any weight on them. The potatoes were thus free from conspicuous pressure spots. Each tuber was marked at 2 places with india ink and the 5 lots were conditioned, one each at 33°, 40°, 45°, 55° and 70° F. for 1 week. The tubers were then bruised at the marked spots by striking them 3 times with the smooth, rounded handle of a screw driver and replaced in the temperature rooms for 2 days. They were then cut and the black spot index was determined as previously described, with results as follows: 474 at 33°, 312 at 40°, 80 at 45°, 51 at 55°, and 36 at 70° F. Thus, again there was a marked reduction in black spot as the conditioning temperature was increased. Although the test was a small-scale one, the results are of particular interest in that, unlike most of the previous tests, bruising was not at pressure spots.

All other temperature studies with the 1948 crop, as well as those with the 1949 crop, were conducted somewhat differently from tests of the previous years. Commercially graded and sacked Green Mountain potatoes grown near Riverhead were trucked to New York City immediately after harvest. Replicate lots were stored in 3 large experimental rooms of a commercial cold storage warehouse at temperatures of 33°, 40° and 50° F. respectively. The bags were set upright without any weight on them. After storage one-bag lots were transferred to lower (where possible) and higher temperatures (including 65° F.), where they were conditioned for one week. At the end of that time approximately 150 tubers from each bag were bruised and then held at prevailing room temperature for 2 days before peeling. The method of bruising was to divide the 150-tuber sample into 2 lots, tie each half-sample loosely in a burlap bag which was placed in a mounted metal drum of 22-inch diameter, and subject the tubers to 20-hand revolutions of the barrel.A 4-inch shelf extending lengthwise on the inside of the drum carried the sample part way around at each revolution of the barrel and thus increased the rolling and tumbling of the tubers. Immediately after the tubers were steam-peeled in a commercial plant they were sorted into classes and a black spot index was determined as described for tests with the 1945 crop.

The black spot index was relatively small, particularly for 8 weeks' storage of the 1948 crop and for 14 weeks' storage of the 1949 crop (Table 4). However, the tests were of particular interest since the potatoes were from the most recent crops used and black spot occurred at various points over the surface of the tubers.

Considering the final temperatures at which the potatoes were held prior to bruising, it will be seen that in all instances the smallest black spot index occurred in either the 65° or the 50° lots; with a single exception the largest index occurred at either 33° or 40° F. The black spot index

of the several lots stored at 33° decreased in size for the most part with increase in the temperature at which they were conditioned prior to bruising. For those lots stored at 40° F., black spot was reduced by conditioning at the two higher temperatures, but was increased in only 2 of 4 instances by conditioning at the lower (33°) temperature. There was little consistency in the results of temperature-conditioning tests made with the potatoes stored at 50° F., which suggests that the effects of storage at this temperature outweighed the effects of conditioning at temperatures either higher or lower than that at which they were stored.

When the tubers were stored at the same temperature before and after bruising the black spot index decreased markedly as temperature increased except in one case (Table 4).

TABLE 4.—*Effect of temperature before and after bruising and of storage period on the development of black spot in 1948-crop and 1949-crop Long Island Green Mountain potatoes.*

Storage Temperature (° F.)	Conditioning Temperature for 1 Week Prior to Bruising (° F.)	Black Spot Index			
		1948 Crop Stored			1949 Crop Stored 14 Weeks
		8 Weeks	12 Weeks	18 Weeks	
33	33	155	332	—	105
	40	135	329	—	70
	50	51	91	—	66
	65	52	109	—	31
40	33	142	200	309	113
	40	154	143	450	57
	50	31	80	105	34
	65	28	87	65	48
50	33	8	38	96	91
	40	15	69	67	53
	50	11	29	112	44
	65	4	14	50	48

TESTS WITH RED RIVER VALLEY POTATOES

While the occurrence of black spot in stored potatoes from the Red River Valley of North Dakota and Minnesota had been noted in previous years, it was not until January 1950 that the disorder became especially prevalent.

Three temperature tests were therefore made at the East Grand Forks, Minnesota, field station in early 1950, using potatoes grown in that area. In the first test, begun on March 27, potatoes of the Triumph and Irish Cobbler varieties were placed in bushel boxes and stored at 3 different temperature ranges, namely 36° to 40°, 56° to 58°, and 65° to 75° F. for

2 days. One-half of the tubers of each variety and at each temperature were bruised slightly by running them over a grader before exposure to the various temperatures; the other half were bruised after the temperature treatment and then returned to their respective temperatures. Twenty-five-tuber lots were used with 4 replications. The tubers were peeled in an abrasion peeler 2 days after bruising and the amount and severity of black spot were determined.

In order that a single figure could be used to represent the amount and severity of black spot present in a given lot, each classification was given an arbitrary number according to the total weight loss resulting from the removal of the defect.

Classification	Weight Loss Resulting from Removal of Black Spot	Assigned Number
Trace	Less than 2 per cent	0.1
Slight	More than 2 and less than 5 per cent	0.2
Moderate	More than 5 and less than 10 per cent	0.5
Severe	More than 10 per cent	1.0

When the per cent of the tubers affected by black spot is multiplied by the classification number, a numerical value is obtained which is termed the black spot index. The larger the figure the greater the amount and severity of black spot.

A 2-day exposure of potatoes of the Irish Cobbler variety to a temperature of 56° to 58° F. prior to bruising significantly reduced the amount of injury from black spot (Table 5). Tubers of the Triumph variety responded differently to the temperature treatment, requiring a temperature of 65° to 75° prior to bruising before any measurable decrease in black spot occurred. While the overall effect of time of bruising was not significant, there was a significant interaction between time of bruising and temperature. Thus, the Irish Cobbler potatoes bruised prior to exposure to 56° to 58° F. developed as much black spot as those at 36° to 40°, whereas the amount of black spot in those bruised after a 2-day exposure to 56° to 58° was much less than those held at the lower temperature. A similar, but less marked response, was noted in the case of the Triumph tubers at the 65° to 75° temperature. The fact that significantly more injury from black spot occurred in the Irish Cobbler than in the Triumph variety substantiates reports of similar observations by commercial storage operators.

In another experiment started on April 1 tubers of the Triumph variety showing pressure spots were carefully removed from the bottom foot of a commercial storage bin in which the potatoes were piled to a depth of

TABLE 5.—*Black spot indexes for Red River Valley potatoes bruised, respectively, before and after a 2-day exposure to the indicated temperatures, March 27, 1950.*

Temperature	Black Spot Index for[1]						
	Triumph		Irish Cobbler		Mean		Temperature
(° F.)	B-1	B-2	B-1	B-2	B-1	B-2	Mean
36-40	3.3	3.2	11.4	20.1	7.35	11.65	9.50
56-58	3.0	4.4	10.4	4.0	6.70	4.20	5.45
65-75	2.7	1.4	5.6	6.4	4.15	3.90	4.02
Variety mean	3.00		9.65		—	—	
B mean	——		——		6..07	6.58	

Least significant difference for temperature: 0.05 = 2.21; 0.01 = 2.98.
No significant difference between times of bruising.
Temperature X time of bruising significant at odds greater than 99:1.
Difference between varieties significant at odds greater than 19:1.
Temperature X variety interaction significant at odds of 99:1.
[1] B-1 = bruised before placing at respective temperature; B-2 = bruised after 2-day exposure to respective temperature.

twelve feet. The experimental plan followed was the same as that described in the preceding experiment.

The amount and extent of injury resulting from the development of black spot were significantly decreased by a 2-day exposure of the potatoes to a temperature of 56° to 58° F. either before or after bruising (Table 6). The higher temperature of 65° to 75° F. tended to reduce the amount of black spot even more than 56° to 58° F., although the difference was not statistically significant. Bruising following exposure to any of the three temperatures resulted in a smaller black spot index than did bruising before this treatment. It is difficult to explain the fact that the potatoes held 2 days at 36° to 40° and then bruised contained less black spot than those bruised immediately after removal from the bin. It may have been that the removal of the pressure from the potatoes brought about a decrease in the amount of black spot. This particular part of the problem was not investigated.

Since the procedure followed in the 2 preceding experiments of returning the potatoes to their respective temperature following bruising would prove impractical commercially, it seemed desirable to obtain some information on the effect of a temporary increase in temperature prior to bruising on the subsequent development of black spot. Therefore, on May 2 an experiment was conducted in which Irish Cobbler tubers previously

TABLE 6.—*Black spot indexes for Red River Valley Triumph potatoes bruised, respectively, before and after a 2-day exposure to three different temperatures, April 1, 1950.*

Temperature (° F.)	Black Spot Index		
	Bruised before Exposure to Respective Temperature	Bruised after Exposure to Respective Temperature	Temperature Mean
36-40	24.5	13.4	18.9
56-58	11.7	6.0	8.8
65-75	10.8	4.0	7.4
Mean	15.67	7.80	

Least significant difference for temperature: 0.05 = 3.05; 0.01 = 4.21.
Time of bruising significant at odds greater than 99:1.
Temperature X time of bruising interaction not significant.

stored at 36° to 40° F. were exposed for 2 days to each of the following temperatures: 36° to 40°, 56° to 58°, and 65° to 75°. These lots were then run over a grader and transferred to a temperature of 36° to 40°, where they remained for 6 days prior to examination for the presence of black spot. Each lot consisted of 25 tubers, with two replications.

Raising the temperature from 36° to 40° to 56° to 58° F. significantly reduced the amount of black spot that developed as indicated by the number of tubers affected with black spot and by the size of the black spot index (Table 7). Although the tubers held at 65° to 75° F. showed less black spot than those at 56° to 58° F., the difference was not statistically significant.

DISCUSSION AND COMMERCIAL APPLICATIONS

The studies here reported clearly show that the prevalence and severity of black spot can be reduced to a great extent by conditioning susceptible

TABLE 7.—*Black spot in Red River Valley Irish Cobbler tubers exposed to various temperatures for 2 days prior to bruising followed by 3 days of exposure to a temperature of 36°-40° F., May 2, 1950.*

Temperature Prior to Bruising (° F.)	Tubers (out of 25) Showing Black Spot	Black Spot
	Number	Index
36-40	18.5	20.2
56-58	3.0	1.2
65-75	1.5	0.6
Least significant difference at 0.05 level	3.0	9.5
Least significant difference at 0.01 level	7.0	—

potatoes for some days at temperatures higher than a normal storage range (prior to bruising). A conditioning temperature range of approximately 50° to 55° was found quite effective, but better results were secured at a temperature range of 65° to 75° F. Complete control, however, was not secured even with the highest temperature employed. The results with Long Island-grown Green Mountain tubers indicate that the length of the conditioning period should be at least 2 to 3 days and preferably about one week. The tests with Triumph and Irish Cobbler potatoes at East Grand Forks were made on the basis of a two-day conditioning period. Some evidence obtained suggests that removal of susceptible tubers to higher temperatures even after they have been bruised will reduce black spot. In none of the tests with Long Island potatoes were similar results secured, so that further work should be carried out before more than tentative conclusions are made regarding this phase of the temperature work. Another very important phase of the problem that needs to be investigated is whether the effects of conditioning can be reversed by subsequent exposure to lower temperatures, followed by further bruising and, if so, to what extent it can occur.

Continuous storage at temperatures above the normal storage range is also effective in reducing black spot after bruising, but much less attention was directed to this phase of the problem than to that of short-time conditioning at higher temperatures.

The extent to which commercial application can be made either of storing susceptible potatoes at temperatures higher than those normally employed or of higher temperature conditioning of potatoes stored at the usual storage temperatures has not been determined. Investigations in progress at East Grand Forks should help answer the question. Until further work is done no commercial recommendations can be made regarding this phase of the black spot problem.

The marked increase in the prevalence and severity of black spot resulting from exposure of susceptible tubers, prior to bruising, to temperatures lower than a normal storage range does suggest very definite commercial recommendations. Thus, where black spot is suspected or known to be of potential importance in a given crop it would be advisable to avoid grading or otherwise handling the potatoes while they are cold. Although 33° F. was the lowest temperature employed in the tests here reported, the slope of the temperature curves suggests that black spot might be expected to be even more serious in potatoes that were extensively handled or bruised while at temperatures between 33° and that of the freezing point of potatoes. Although 40° is the ideal temperature aimed at in commercial storage houses, temperatures in portions of the bins are sometimes 32° or lower.

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THE COMPARATIVE EFFICIENCY OF TUBER INDEXING AND TUBER UNIT PLANTING IN THE ELIMINATION OF VIRUS DISEASES FROM SEED POTATOES[1]

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Two methods have been used extensively for the detection and elimination of virus diseases in seed potatoes, namely tuber indexing and tuber unit planting.

Tuber unit planting, the older of the two methods, was advocated by Webber (14) in 1908 as a means of selection in potato breeding work. The value of the method for the purpose of controlling virus diseases in seed potatoes was pointed out by Askegaard (1), Harrington (6), and others. It has become a standard practice for seed plots and the production

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of foundation seed. The method consists of planting consecutively in a row all seed pieces (usually four) cut from each tuber, and separating these seed pieces from those of the adjoining units by means of a stake or an extra space. Machines have been developed for planting seed in this way. Periodic inspections are made during the growing season and all infected plants are rogued. When one or more plants in a unit exhibit symptoms of a virus disease, the entire unit is removed. Thus tuber unit planting makes it possible to remove all plants produced by an infected tuber despite the fact that all of them may not show symptoms. Virus-infected plants, being stunted generally, tend to be overshadowed by healthy plants, but where the tubers are planted as units this cannot happen.

The tuber index method for virus disease control was first described by Blodgett and Fernow (3) in 1921. Since that date, the practice has been adopted generally in the seed-producing areas of Canada and the United States (2). The method consists of removing from each tuber a small piece bearing a single eye, and planting it in the greenhouse during the winter months. In the southern parts of United States indexing can be performed outdoors (5). If the plant produced by the seed piece develops symptoms of any virus disease, then the tuber, from which the piece was cut, is discarded. Only those tubers the seed pieces of which produced normal plants in the greenhouse, are saved for planting in the field in the spring. They are usually planted by tuber units in seed plots where the stock is multiplied for the following year's planting.

The chief advantages of tuber indexing are: (1) low light intensity during the winter and spring months permits clear expression of virus symptoms that tend to become masked in summer by intense light or high temperatures; (2) uniform cultural conditions and absence of other diseases and insect damage in the greenhouse favor the detection of virus symptoms; and (3) removal of virus-bearing tubers from a seed stock before it is planted greatly reduces the number of virus-infected plants in the seed plot where they would constitute sources of infection for the healthy plants. The method has certain obvious disadvantages, chief of these being the expense involved and the fact that only a limited number of tubers can be handled.

It was to ascertain whether or not the extra cost and labor connected with tuber indexing were warranted that the present work was undertaken. Several workers (4, 7, 8, 10, 11, 12, 13, and 15) have reported substantial reductions of virus diseases in seed stocks through tuber indexing, and agreed that it was superior to tuber unit planting in this respect. No direct quantitative comparison of the efficiency of the two methods however, has apparently been made over a period of years. Such a comparison was conducted at Ottawa over a five-year period. In this locality, conditions

are not favorable for the maintenance of virus-free seed potato stocks because of frequent heavy aphid infestations.

Materials and Methods

The original source of material was a quantity of Green Mountain seed potatoes, Certified grade. This stock was chosen because it was desired to begin with seed potatoes of good quality, but which would not be entirely free from virus diseases. One thousand tubers from this lot were indexed in the greenhouse and planted by tuber units in the field in 1944, and 1000 tubers from those plants that remained apparently healthy in the field were indexed the next and each succeeding year. One thousand similar tubers were planted by tuber units in the field without indexing in 1944, and 1000 tubers of the progeny of those that were not rogued as diseased were planted by tuber units each succeeding year.

The tubers to be indexed were first numbered consecutively with an indelible pencil. One eye was then scooped from each potato tuber with a vegetable baller, which was disinfected with 5 per cent Lysol after each cut. Each seed piece was then planted in a 4-inch pot labelled to correspond with the number on the tuber. Daylight was supplemented by electric light during part of each night. After the plants emerged, they were inspected at weekly intervals over a period of approximately two months. Records were kept of all virus diseases as symptoms appeared, and infected plants were removed immediately. The tubers from which seed pieces had produced healthy plants in the greenhouse were cut into four sets and planted by tuber units in a field plot that season.

In order to compare greenhouse symptoms with those occurring under field conditions, and as a further check on the efficiency of tuber indexing, the tubers that were removed from the indexed stock because of virus infection were also planted in the field by tuber units under their original numbers, but in a plot well isolated from the seed plots. This disease plot was inspected regularly and complete records were kept of all virus-infected plants. All of the crop from this plot was discarded.

Each tuber of the tuber unit stock was cut into four sets which were planted as a unit. For convenience in taking records, the stakes separating the units were numbered consecutively.

The tuber index and the tuber unit plots were adjacent to each other in the field each year, except for 3 rows of corn, in order that soil conditions in both plots would be as comparable as possible. The corn was planted to check the migration of insects from one plot to the other. The two plots received identical cultural and spray treatments. Both plots were carefully inspected and rogued throughout the season, and complete records were kept of the incidence of virus diseases.

A representative sample of tubers was obtained for the next season's

tests by keeping at harvest time one tuber from each plant of the remaining units in each plot. From the tubers of the indexed stock thus obtained, 1000 tubers were selected at random for indexing the following year. Similarly, 1000 tubers were selected from the tuber unit stock for planting the next season.

Experimental Results

First Season

The virus disease readings taken in the greenhouse and in the field in 1944 are summarized in table 1. Only 658 of the 1000 tubers that were indexed were saved for planting in the healthy seed plot. Ninety per cent of the index plants that were rated as "doubtful" showed a very faint mottling. When these same plants were transplanted outdoors, however, the mottling disappeared. Furthermore, no such mottling was evident in any of the units planted with the original tubers. This condition was possibly what other workers have called "supermild mosaic" (Potato virus X) or "weather mottle". Werner (15) encountered a similar condition in tuber index experiments and was able to eliminate it almost entirely from his seed stock by indexing. This type of mottle was not found again during the course of the experiments. The growing conditions in the greenhouse in 1944 may have favored the expression of this symptom.

Six units were rogued from the healthy indexed plot during the season because they appeared doubtful, although no virus disease was positively

Table 1.—*Comparison of virus disease readings in indexed and non-indexed potatoes, 1944*

Classification	Indexed Stock			Non-indexed Stock (No. of Units)
	Greenhouse Readings (No. of Plants)	Field Readings (No. of Units)		
		Healthy Plot[1]	Disease Plot[2]	
Healthy	658	652	302	936
Leaf roll	10	0	20	14
Rugose mosaic	7	0	6	13
"Fern leaf"	1	0	1	0
Doubtful	252[4]	6	13	37
Missing	72	0	0	0
Total Virus Infection (Per cent)	1.8	0	2.7	2.7

[1] Seed plot planted with tubers that produced normal index plants.
[2] Isolated plot planted with tubers discarded from seed stock in indexing.
[3] Unusual symptom, believed to be due to virus.
[4] Most of these plants showed a faint mottling which may have been an expression of Potato Virus X.

identified. In the disease plot, 2.7 per cent of the original tubers produced obviously virus-infected plants. The same percentage of virus infection was found in the non-indexed tuber unit plot.

Second Season

According to the greenhouse readings taken in 1945, 4.5 per cent of stock was infected with virus (Table 2). By adding together the percentage infection found in the two field plots planted with these tubers, a total field reading of 3.8 per cent was obtained. This would indicate that the virus content of the indexed stock was not essentially different from that of the non-indexed stock at the beginning of the second season.

Third Season

The greenhouse and field readings taken in 1946 are presented in table 3. The indexed stock showed 7.5 per cent virus infection in the greenhouse, and 8.8 total infection in the field, of which 1.4 per cent was found in the healthy seed plot. The non-indexed stock, on the other hand, had a virus content of 29.9 per cent. Leafroll was the most prevalent disease this season, followed by rugose mosaic. These diseases had evidently spread early in the previous season before roguing was completed. A small amount of bunch top (purple top), resulting from current-season infection, was found in the field plots in 1946.

Fourth Season

The virus content of both stocks dropped sharply in 1947 (Table 4). The indexed stock showed only 2.2 per cent infection in the greenhouse, and a total of 2.7 per cent in the field, with only 0.6 per cent appearing

TABLE 2.—*Comparison of virus disease readings in indexed and non-indexed potatoes, 1945*

Classification	Indexed Stock			Non-indexed Stock (No. of Units)
	Greenhouse Readings (No. of Plants)	Field Readings (No. of Units)		
		Healthy Plot	Disease Plot	
Healthy	943	929	26	958
Leaf roll	30	7	16	25
Rugose mosaic	9	1	9	10
Mild mosaic	4	0	2	1
Leafrolling mosaic	2	1	2	3
Doubtful	9	0	0	0
Missing	3	5	2	3
Total Virus Infection (Per cent)	4.5	0.9	2.9	3.9

TABLE 3.—*Comparison of virus disease readings in indexed and non-indexed potatoes, 1946*

Classification	Indexed Stock			Non-indexed Stock (No. of Units)
	Greenhouse Readings (No. of Plants)	Field Readings (No. of Units)		
		Healthy Plot	Disease Plot	
Healthy	925	911	1	701
Leaf roll	44	6	34	199
Rugose mosaic	28	4	25	52
Mild mosaic	2	1	2	17
Leafrolling mosaic	1	1	13	25
Bunch top[1]	0	2	0	6
Total Virus Infection (Per cent)	7.5	1.4	7.4	29.9

[1] Current-season infection.

in the healthy plot. The virus content of the non-indexed stock was not reduced to the same extent, 8.9 per cent of these tubers still being infected. In late August many plants in both the indexed and the non-indexed plots showed symptoms suggesting current-season infection with the bunch top (purple top) virus. These symptoms were confined to the top portion of an affected plant and frequently appeared on only one or two branches. It was not considered practical to rogue such plants so late in the season, and no record was made of the number of plants affected.

Fifth Season

In 1948, the final year of the experiment, the indexed stock showed only 1.4 per cent infection in the greenhouse (Table 5). The same amount was found in the disease plot, but an additional 2.6 per cent developed in the healthy plot, as will be explained later, and therefore the total field reading for this stock was 4.0 per cent. Again the virus content of the indexed stock was far below that of the non-indexed stock, which had 16.4 per cent infection.

For the first time in the course of the experiment, evidence of tuber transmission of the bunch top (purple top) virus was obtained. The secondary symptoms were much more acute than those following current-season infection, and they were obvious from the time of plant emergence. The plants were extremely stunted and chlorotic, with thickened nodes, stiff, rolled leaves, and abundant aerial tubers. Two index plants displayed these symptoms in the greenhouse in 1948. When the corresponding tubers were planted in the field, however, one produced four plants like its index plant, whereas the other produced two infected and two apparently healthy

plants in the same unit. The underground tubers produced by the bunch top plants were all less than three-fourths inch in diameter. Five units in the healthy indexed plot also had from one to four plants showing secondary symptoms of bunch top, despite the fact that their index plants appeared normal. In addition, six units in the non-indexed plot had one or more plants showing acute bunch top. It is evident, therefore, that the virus causing this disease was not always uniformly distributed throughout the tubers that transmitted it from the previous season's infection.

TABLE 4.—*Comparison of virus disease readings in indexed and non-indexed potatoes, 1947*

Classification	Indexed Stock			Non-indexed Stock (No. of Units)
	Greenhouse Readings (No. of Plants)	Field Readings (No. of Units)		
		Healthy Plot	Disease Plot	
Healthy	978	972	1	911
Leaf roll	14	1	13	49
Rugose mosaic	4	0	4	19
Mild mosaic	2	5	4	17
Leafrolling mosaic	2	0	0	3
Bunch top	0	0	0	1
Total Virus Infection (Per cent)	2.2	0.6	2.1	8.9

TABLE 5.—*Comparison of virus disease readings in indexed and non-indexed potatoes, 1948*

Classification	Indexed Stock			Non-indexed Stock (No. of Units)
	Greenhouse Readings (No. of Plants)	Field Readings (No. of Units)		
		Healthy Plot	Disease Plot	
Healthy	986	960	0	836
Leaf roll	7	2	7	15
Rugose mosaic	1	0	1	14
Mild mosaic	1	0	1	5
Leafrolling mosaic	3	0	3	1
Bunch top	2	8	2	8
Leaf-drop streak*	0	16	0	121
Total Virus Infection (Per cent)	1.4	2.6	1.4	16.4

* Current-season symptom of rugose mosaic.

Another rather unusual disease that appeared only in this final year was leaf-drop streak, which is the current-season expression of rugose mosaic (Potato virus X + Y). Since this infection had not been transmitted through the tubers, usually only one plant in a unit, and frequently only one branch of a plant, showed symptoms. On July 30, two plants from the indexed healthy plot and 106 from the non-indexed plot were rogued for leaf-drop streak. Two weeks later, 15 additional plants from the indexed plot and 25 from the non-indexed plot were rogued for the same reason. The infected plants appeared to be concentrated most heavily at one end of the non-indexed plot, adjacent to a poplar and spruce windbreak behind which was an apple orchard in sod. It was first postulated that an insect vector was bringing the disease into the potato plots from some weed host located in the windbreak or orchard. When the position of each infected potato plant was marked on a chart, however, it was seen that the distribution pattern for leaf-drop streak followed exactly the distribution of the 14 units that were rogued on June 28 for rugose mosaic (Fig. 1). Through chance, the distribution of the 14 units among the 1,000 was far from uniform. Each rugose mosaic plant constituted a primary source of infection for those plants that later developed leaf-drop streak. Since no tuber carrying rugose mosaic was planted in the healthy indexed plot, all current-season infection found there had as its source the adjacent non-indexed plot. Such spread must have taken place before June 28 when all rugose mosaic plants were rogued. The 3-row corn barrier was obviously ineffective against migrating insects that early in the season. The greatest distance between any leaf-drop streak plant and the nearest rugose mosaic plant was approximately 50 feet. A winged form of aphid is believed to have been the vector responsible for the dissemination of the disease from the primary infection centers.

Five-year Comparison

The virus contents of the indexed and non-indexed stocks are presented in diagrammatic form in figure 2 in order that they might be compared directly over the 5-year period. There was virtually no difference between the stocks as to virus content in the first and second years, but in all succeeding years the amount of disease in the non-indexed stock exceeded that of the indexed stock. The greatest difference in disease levels was found in the third year The average virus content of the indexed stock was 4.4 per cent as compared with 12.4 per cent for the non-indexed. The average infection (including current-season) found in the healthy indexed plot was 1.1 per cent.

Discussion

Under the conditions of the experiments conducted at Ottawa, there was no marked difference between the tuber index and the tuber unit

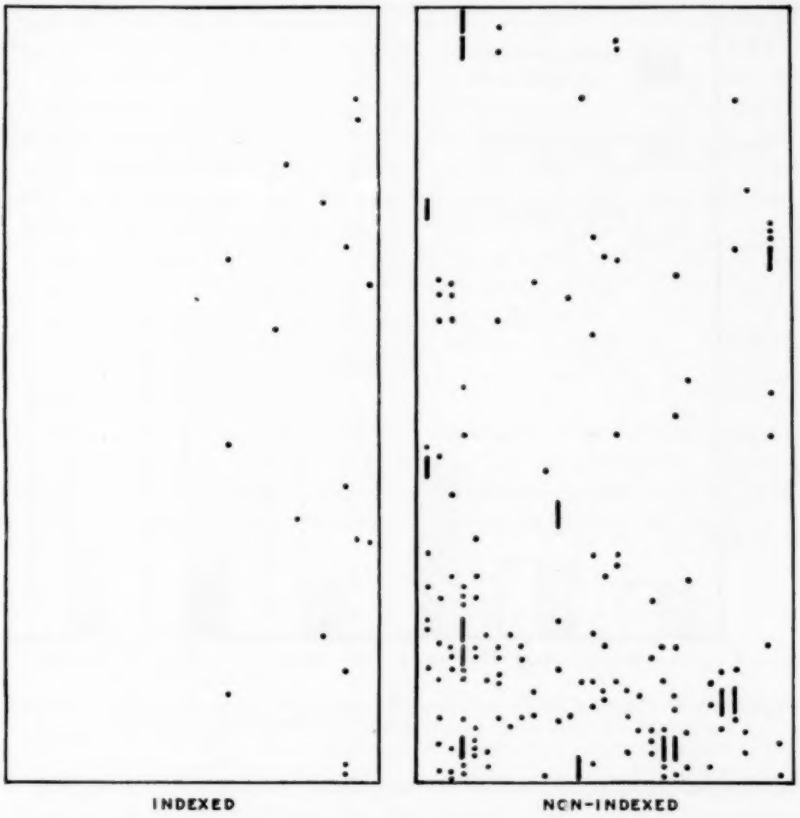

Fig. 1. Distribution of rugose mosaic and leaf-drop streak in plots planted with indexed and non-indexed Green Mountain potatoes at Ottawa, 1948. Each short line marks position of one unit of four plants infected with rugose mosaic which was rogued June 28. Each dot marks location of one plant rogued July 30 or August 13 because of leaf-drop streak.

methods as to the degree of accuracy in detecting virus diseases in seed potatoes. In general, mild mosaic was more readily detected in the greenhouse, whereas leafroll was more readily recognized in units in the field. Both methods should be employed for maximum efficiency in eliminating virus diseases.

The chief advantage of the tuber index method indicated by these experiments was that the stock purified in this way did not become reinfected as readily as non-indexed stock. The only opportunity for either stock to become infected with virus was in the field during the growing season. The only difference in treatment was that practically all virus-

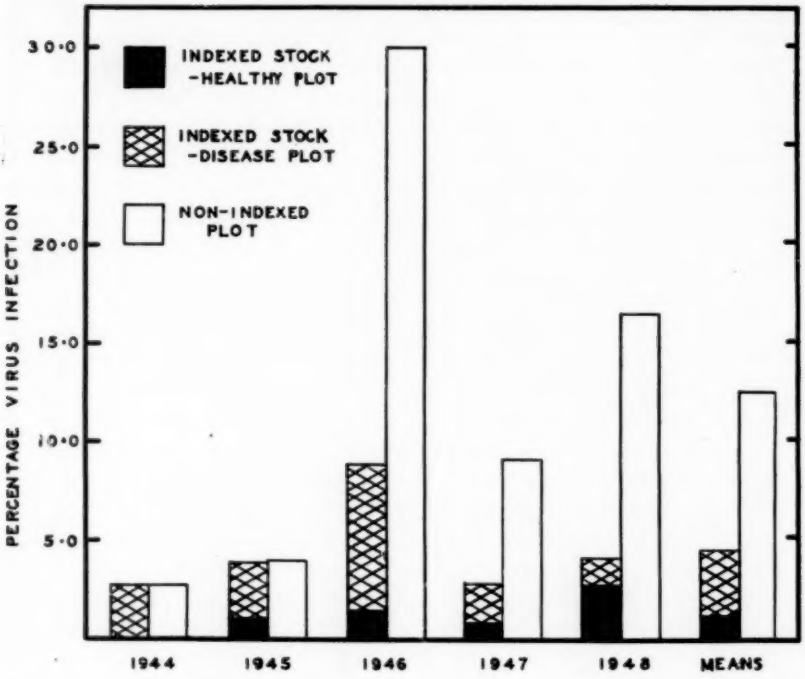

Fig. 2 Virus content of indexed and non-indexed stocks of Green Mountain potatoes as indicated by field readings during five consecutive seasons at Ottawa.

bearing tubers were removed from the indexed stock before it was planted in the field, whereas such tubers in the non-indexed stock were planted in the same plot with the healthy ones. Up to the time that they were rogued, the plants from these virus-bearing tubers were a potential source of infection for the healthy plants. Dissemination would depend on the presence of appropriate insect vectors during this period. Such conditions evidently prevailed in the spring of 1945 to account for the drastic increase in the virus content of both stocks (particularly the non-indexed) in 1946.

The outbreak of leaf-drop streak in the final year was a striking demonstration of dissemination of a virus disease from primary infection centers. That which took place with this disease was in all probability happening with other virus diseases at the same time, but the effects would not be apparent until the following season. This outbreak also emphasized the importance of early roguing and of complete isolation for seed plots. The isolation strip between the indexed and non-indexed plots, even though planted with corn, was obviously not effective. If the indexed

plot had been effectively isolated, lower virus readings would undoubtedly have been obtained for this stock throughout the experiment.

The practice of tuber indexing is based on the premise that a virus is uniformly distributed throughout an infected tuber so that every eye will produce an infected plant. The results obtained with respect to bunch top demonstrated that this is not true of the virus causing this disease, since both healthy and infected plants were grown from the same tuber in several instances. MacLeod (9) reported that frequently only a part of a tuber may be infected and be involved in transmitting the virus. He also noted a similarity between the secondary phase of this disease and the condition described as "haywire". Although the index method cannot be relied upon to detect and eliminate bunch top completely, this is likely to be of little commercial importance since the disease is rarely transmitted through the tubers.

In general, it may be stated that the tuber index method possesses sufficient advantage over the tuber unit method for maintaining the purity of seed potato stock to warrant the additional cost and labor involved, especially in areas where the vectors of potato viruses are prevalent.

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PROGRAM OF THE ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

December 11, 12, 13, 1951

Netherlands-Plaza Hotel

Cincinnati, Ohio

Tuesday Morning, December 11, Netherlands-Plaza Hotel, Parlor H, 9:00 A.M.

G. H. RIEMAN, *Chairman*

1. *Nine years of zinc ethylene bisdithiocarbamate on potatoes in Delaware.* (15 min.) J. W. HEUBERGER, University of Delaware, Newark, Delaware.
2. *Comparison of certain standard and experimental fungicides in potato late blight control.* (15 min.) J. H. MUNCIE, Michigan State College, East Lansing, Michigan.
3. *Early blight control with differently prepared carbamates.* (15 min.) J. D. WILSON, Ohio Agricultural Experiment Station, Wooster, Ohio.
4. *Tuber symptoms of Calico.* (10 min.) C. M. SLAGG, Kansas State College, Manhattan, Kansas.
5. *Some suggestions for indexing potato tubers.* (10 min.) AVERY E. RICH and S. B. LOCKE, University of New Hampshire, Durham, New Hampshire.
6. *A machine for planting potatoes in tuber units.* (8 min.) R. A. JEHLE, University of Maryland, College Park, Maryland..
7. *Report of three years testing of insecticides for the control of aphids on potatoes.* (15 min.) LESLIE B. DANIELS, Colorado Agricultural and Mechanical College, Fort Collins, Colorado.
8. *Verticillium wilt and seed potato certification.* (15 min.) BERNARD BARIBEAU, Division of Plant Protection, Department of Agriculture, Ste. Anne de la Pocatiere, Quebec, Canada.
9. *An extension program to eliminate ring rot.* (15 min.) O. L. WYMAN, University of Maine, Orono, Maine.
10. *A successful foundation seed farm.* (8 min.) PAUL EASTMAN, Maine Department of Agriculture, Augusta, Maine.
11. *"Better seed".* A sound movie. (22 min.) Maine Department of Agriculture, Augusta, Maine.

Tuesday Afternoon, December 11, Netherlands-Plaza Hotel, Parlor H, 1:30 P.M.

Joint Session with Section E of the American Phytopathological Society.

REINER BONDE, *Chairman*

1. *Factors influencing tuber discoloration following vine killing.* (15 min.) WILLIAM G. HOYMAN, U.S.D.A., North Dakota State Seed Department, and North Dakota Agricultural Experiment Station, Fargo, North Dakota.
2. *The development of races of Phytophthora infestans (Mont.) deBary on potato hybrids.* (15 min.) W. R. MILLS and L. C. PETERSON, Pennsylvania State College and Cornell University, State College, Pennsylvania, and Ithaca, New York.

3. *Mutations of potato virus X induced by nitrogen mustard.* (15 min.) R. H. LARSON, M. A. STAHMANN, J. C. WALKER and R. W. COLBURN, University of Wisconsin and U.S.D.A., Madison, Wisconsin.
4. *Immunological and histological relationship between strains of the potato leaf roll virus.* (15 min.) R. E. WEBB and R. H. LARSON, University of Wisconsin and U.S.D.A., Madison, Wisconsin.
5. *Fungicidal treatment of seed potatoes after cutting.* (15 min.) AVERY E. RICH, University of New Hampshire, Durham, New Hampshire.
6. *Studies of dry fungicides on cut potato seed pieces.* (12 min.) GEORGE H. LANE, Colorado Agricultural and Mechanical College, Fort Collins, Colorado.
7. *Effects of seed-piece treatment on yields and seed-piece decay of potato.* (10 min.) DONALD S. OLMSTED, Minnesota Agricultural Experiment Station, St. Paul, Minnesota.
8. *Control of potato seed-piece decay by seed-piece treatment.* (15 min.) ROY A. YOUNG and J. A. MILBRATH, Oregon State College, Corvallis, Oregon.
9. *Internal browning of Netted Gem potatoes in California.* (15 min.) JAMES B. KENDRICK, SR., University of California, Davis, California.
10. *Internal browning of potatoes as affected by date of planting and storage.* (15 min.) J. HOWARD ELLISON, Long Island Vegetable Research Farm, Cornell University, Riverhead, New York.
11. *Persistence of scab-resistance in potato varieties.* (15 min.) G. H. RIEMAN, R. W. HOUGAS and G. STOKES, University of Wisconsin, Madison, Wisconsin.
12. *Mycorrhiza-like mycelium in potato tubers.* (15 min.) D. C. COOPER, G. H. RIEMAN, R. W. HOUGAS, G. W. STOKES and E. C. GASIORKIEWIEZ, University of Wisconsin, Madison, Wisconsin.
13. *Verticillium wilt of potatoes.* (15 min.) G. W. AYERS, Dominion Laboratory, Plant Pathology, Charlottetown, Prince Edward Island, Canada.
14. *Results of testing lines and varieties of potatoes for field resistance to verticillium wilt.* (15 min.) JOHN G. McLEAN, U.S.D.A., Idaho Branch Experiment Station, Aberdeen, Idaho.
15. *Inoculation of potatoes with ring rot tissue from different sources.* (10 min.) CHARLES E. LOGSDON, Minnesota Agricultural Experiment Station and U.S.D.A., St. Paul, Minnesota.

Wednesday Morning, December 12, Netherlands-Plaza Hotel, Parlor H, 9:00 A.M.

REINER BONDE, *Chairman*

Presidential Address, REINER BONDE

Business Meeting

- Report of Secretary — Ora Smith
- Report of Treasurer — J. C. Campbell
- Report of Editor, American Potato Journal — Wm. H. Martin
- Report of Certification Committee — H. M. Darling
- Report of Potato Introduction Committee — G. H. Rieman
- Report of Editorial Committee — O. D. Burke
- Report of Membership Committee — Marx Koehnke
- Report of Resolutions Committee
- Report of Auditing Committee
- Granting Honorary Life Memberships
- New Business

Report of Nominating Committee — Marx Koehnke
Election of Officers
Seed Certification Problems — H. M. Darling, Chairman

Wednesday Afternoon, December 12, Netherlands-Plaza Hotel, Parlor H, 1:30 P.M.

C. E. PETERSON, *Chairman*

1. *Recent developments in the use of portable irrigation systems in potato production areas.* (20 min.) ARTHUR J. PRATT, Cornell University, Ithaca, New York.
2. *Effect of irrigation on the chemical composition of the potato plant.* (15 min.) R. A. STRUCHTEMEYER, University of Maine, Orono, Maine.
3. *The influence of irrigation on the yield and quality of potatoes on Long Island.* (15 min.) W. C. JACOB, M. B. RUSSELL, A. KLUTE, G. LEVINE and R. GROSSMAN, Long Island Vegetable Research Farm, Cornell University, Riverhead, New York.
4. *The results of three years of potato irrigation tests in various parts of Upstate New York.* (20 min.) ARTHUR J. PRATT, Cornell University, Ithaca, New York.
5. *The effects of tillage practices on the yields of Irish Cobbler potatoes.* (15 min.) W. C. JACOB and M. B. RUSSELL, Long Island Vegetable Research Farm, Cornell University, Riverhead, New York.
6. *Results of two years' potato fertilization experiments in Upstate New York.* (15 min.) M. W. MEADOWS, Cornell University, Ithaca, New York.
7. *Factors affecting the numbers of potato tubers growing to marketable size.* (15 min.) G. L. TERMAN, C. E. CUNNINGHAM and R. A. STRUCHTEMEYER, University of Maine, Orono, Maine.
8. *Factors affecting number, size and yield of potatoes.* (15 min.) E. H. CASSERES and ORA SMITH, Cornell University, Ithaca, New York.
9. *Effect of field applications of maleic hydrazide on potatoes in storage and for seed purposes.* (15 min.) E. J. KENNEDY and ORA SMITH, Cornell University, Ithaca, New York.
10. *Inhibition of potato sprouting by 2,3,5,6-tetrachloronitrobenzene and methyl ester of a-naphthaleneacetic acid.* (10 min.) J. HOWARD ELLISON, Long Island Vegetable Research Farm, Cornell University, Riverhead, New York.
11. *Yield and specific gravity of potato varieties in Connecticut trials. 1948-1950.* (15 min.) ARTHUR HAWKINS, Storrs Agricultural Experiment Station, Storrs, Connecticut.
12. *The relationship of specific gravity of six varieties of potatoes to their mealiness as assessed by sensory methods.* (15 min.) MARY L. GREENWOOD, MARGARET H. McKENRICK, and ARTHUR HAWKINS, Storrs Agricultural Experiment Station, Storrs, Connecticut.
13. *A fertilizer drilling machine for potato plot work.* (20 min.) W. T. SCUDDER, Clemson College Truck Experiment Station, Charleston, South Carolina.

Thursday Morning, December 13, Netherlands-Plaza Hotel, Parlor H, 9:00 A.M.

O. L. WYMAN, *Chairman*

1. *Weed control and cultivation experiments on potatoes.* (15 min.) C. E. CUNNINGHAM, University of Maine, Orono, Maine.
2. *Chemical weed control in potatoes.* (15 min.) ORA SMITH, E. J. KENNEDY, J. R. ORSENIGO and R. F. FOLEY, Cornell University, Ithaca, New York.
3. *Free amino acids in potato tubers altered by 2,4-D treatment of plants and its significance in the mechanism of action of 2,4-D.* (12 min.) MERLE G. PAYNE, JESS L. FULTS and RUTH J. HOY, Colorado Agricultural and Mechanical College, Fort Collins, Colorado.

4. *Relation of soluble nitrogen fractions to black spot of potatoes.* (15 min.) C. H. VAN MIDDELEM, Cornell University, Ithaca, New York.
5. *Varietal susceptibility to internal black spot of potatoes.* (10 min.) P. H. MASSEY, JR., H. C. THOMPSON and ORA SMITH, Cornell University, Ithaca, New York.
6. *Response of the potato to certain growth substances.* (15 min.) E. J. KENNEDY and ORA SMITH, Cornell University, Ithaca, New York.
7. *Studies on potato foliage development.* (15 min.) R. A. KELLEY, J. B. ADAMS and P. H. BAIRD, Field Crop Insect Laboratory, Department of Agriculture, Fredericton, New Brunswick, Canada.
8. *Influence of vine killing on yield, specific gravity and vascular discoloration in potatoes.* (10 min.) C. E. PETERSON, U.S.D.A., Ames, Iowa and ARAL B. GWINN, Iowa State College, Ames, Iowa.
9. *Factors affecting color of potato chips.* (15 min.) R. S. SHALLENBERGER and ORA SMITH, Cornell University, Ithaca, New York.
10. *Dehydration of potatoes in alfalfa-type driers for production of feed.* (20 min.) PAUL W. EDWARDS, A. HOERSCH, JR., C. S. REDFIELD and R. K. ESKEW, Eastern Regional Research Laboratory, U.S.D.A., Philadelphia, Pennsylvania.
11. *Methods of setting seed on Russet Burbank potatoes.* (10 min.) JOHN G. McLEAN, U.S.D.A., Aberdeen, Idaho.

Thursday Afternoon, December 13, Netherlands-Plaza Hotel, Parlor H, 1:30 P.M.

Joint Session with American Association of Economic Entomologists.

Co-chairmen: B. B. PEPPER *and* ORA SMITH

1. *Fundamental and practical aspects of insects as vectors of potato diseases.* (30 min.) F. F. SMITH, U.S.D.A., Beltsville, Maryland.
2. *Plant feeding potato insect pests and their control by chemicals and sanitary and cultural measures.* (30 min.) D. M. DeLONG, Ohio State University, Columbus, Ohio.
3. *Insect production problems of potatoes in the East.* (30 min.) J. P. SLEESMAN, Ohio Agricultural Experiment Station, Wooster, Ohio.
4. *Insect production problems of potatoes in the West.* (30 min.) A. A. GRANOVSKY, University of Minnesota, St. Paul, Minnesota.
5. *Soil insecticides in relation to potato insect control and the quality of potatoes.* (30 min.) B. B. PEPPER, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey.

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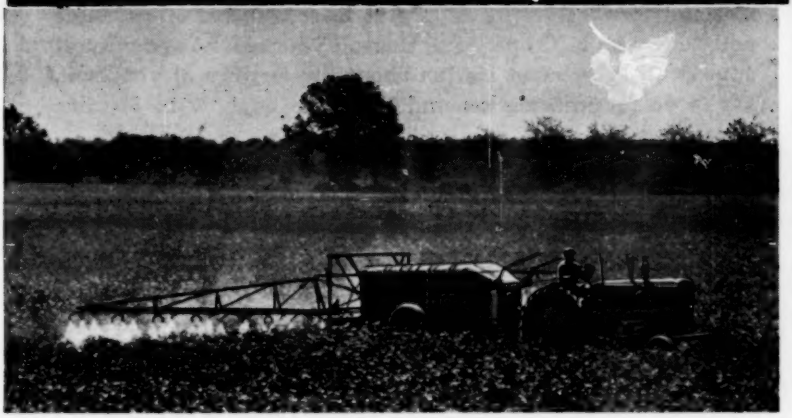

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